Problems in Extraterrestrial Communication

by

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INTRODUCTION

It is a truism of information theory that for communication to occur, there must be some commonality, some sharing between sender and receiver. The commonality may derive from perception, from cognition, from experience, but there must be a common reference point upon which to build shared meaning. In the absence of such a mutual point, all messages are unique and no information can be exchanged, since there is no means to decode it. This situation, or something very much like it, may very well obtain when we first encounter extraterrestrial intelligence.

Communicating with extraterrestrials is a science fiction theme that is both current and venerable. Hugo Gernsback, the father of contemporary science fiction, wrote stories in which he suggested some of the communication differences that might be encountered with aliens or with robots. Since the thirties, most science fiction treatments of the problems involved in communication with extraterrestrials have suggested that the major difficulty to be encountered is a cultural/psychological one. Commonly two species are operating under different assumptions, sometimes with different biological substrates; each persistently misinterpreting the actions of the other. The resolution of the difficulty comes when the misinterpretation is recognized and taken into account.

Part of my purpose in this paper is to suggest that the difficulties inherent in extraterrestrial communication will likely be much more basic, more profound, and more difficult to resolve than has generally been envisioned thus far. Not surprisingly, our conceptions of encounters with extraterrestrials generally reflect our assumptions about communication, and are modeled on our own experiences. Thus, anthropology with its concern for cultural differences and a relativistic appreciation of these dissimilarities frequently supplies the intellectual model for cross-species encounters. Communication difficulties are usually attributed to differing cultural backgrounds, experiences and assumptions. Those projections that come closer to the mark also acknowledge the contribution that differing biologies can make not only to behavior, but to thought. Our own capacities and limits as a species are embedded in our biological nature, and it is reasonable to expect that this will be the case for other life forms as well.

In addition to describing the problem of extraterrestrial communication, I also wish to suggest a means of dealing with (solving?) it. Since the seventies, the possibility of communicating with life forms beyond our planet has garnered increasing attention in the community of scientists. From the inclusion of pictures, music, earth sounds, and spoken greetings that were included on the first Voyager, to

the current efforts of the SETI (Search for Extraterrestrial Intelligence) project, the issue of communication with extraterrestrials has become more of a concern for the scientific community and less the exclusive domain of science fiction (Morrison, et al. 1977, Sagan 1973). Thus, while this essay is admittedly speculative, I can hope that it will play a constructive role in the task of conceptualizing and implementing attempts at extraterrestrial communication.

HUMAN LANGUAGE AND ITS BIOLOGICAL SUBSTRATE

True language, with its generative grammar and reliance on symbols, is widely regarded by anthropologists, linguists and others, as a distinguishing characteristic of our species (Miller 1981). Human language has the capacity to generate new meaning and to allow language users to exchange messages that are at once unique, yet decipherable (Eastman 1978, Miller 1981). Human language has two principal qualities that account for this capability.

First, humans are capable of associating sound and meaning in an arbitrary fashion. Unlike closed-call systems, where animals communicate with utterances that convey emotional states, humans can wed non-emotional meaning to a pattern of sounds in a fashion that is wholly arbitrary. This frees us from the constraints of environmental stimuli and allows us to create new meanings. If the relationship between sound and meaning is not biologically embedded (as a cry of fright would be) then language users can create novel references, and begin to generate culture, a learned constellation of symbolic meanings.

Second, human language possesses a characteristic that Chomsky describes as an underlying deep structure that enables language users to send and to receive meaningful messages that may never before have been sent or received (Chomsky 1957, Chomsky 1972). Chomsky and others have argued that the deep structure for language is the same for all humans, and accounts for phonological, structural, and even semantic universals that can be found across human languages as diverse as English, Urdu and Malay (Brown 1991, Chomsky 1972, Greenberg 1963, Greenberg 1966, Ullman 1963). Over the past twenty years, considerable evidence has accumulated that people use very diverse languages in very similar ways and that the semantic distinctions underlying these divergent languages are essentially universal (Herrmann and Raybeck 1981, Osgood, et al. 1975, Raybeck and Herrmann 1990).

There is a clear argument that there exists a human language, capable of great elasticity and productivity, yet nonetheless, distinctively structured and ultimately

constrained by a deep structure that is "wired-in" (Ardila and Ostrosky-Solis 1989, Bloom and Lazerson 1988, Chomsky 1972, Hanlon and Brown 1989, Jerison 1990, Laughlin and D'Aquili 1974, Marin 1982). In short, there are limits on human language: there are limits on the messages we can send or receive, and there are limits on our ability to process information. These are part of our human heritage.

The human capacity for language is not simply learned, but depends on identifiable neural structures in the brain (Ardila and Ostrosky-Solis 1989, Hanlon and Brown 1989, Lenneberg 1967, Marin 1982, Thompson and Green 1982). The capacities for understanding speech and for generating it are separately localized, usually in the left hemisphere (Geschwind 1990). These areas, Broca's and Wernicke's respectively, are well connected by a neural network, and there are also connections to other areas of the brain that process and store information concerning vision, proprioception, touch, etc. (Geschwind 1990, Laughlin and D'Aquili 1974, Stokoe 1989). Further, localization of language functions in the brain appear to be sites of motor functions as well (Ojemann 1982).

Twenty-five years ago Lenneberg succeeded in demonstrating that the development of language skills follows an immutable path that correlates very strongly with the development of motor skills (1967). Ojemann has gone so far as to argue that the brain sites involved in language processing are associated not only with motor function, but also with short-term memory (1982). I appreciate that the reader may find these arguments a bit abstruse, but the point to be made here is important. It is becoming increasingly apparent that there exist neurological structures that serve as correlates for those capacities we recognize as language (Hanlon and Brown 1989, Marin 1982, Premack 1986).

Our communication abilities, and very likely our general cognitive abilities, are to a significant extent "hard wired" in a fashion that gives us great flexibility, yet also implies distinct limits on our capacities for language and for thought. More than thirty years ago George Miller established a strong argument that the human capacity to process information is limited. He suggested that we have difficulty in managing more than seven cognitive distinctions at one time, and that the reason for this limitation was probably located in the physiological substrate of the brain (Miller 1956).

There is also evidence that those logical relationships that we regard as essential to meaning are probably a reflection of underlying neurophysiology (Premack 1985, Premack 1986, Pribram 1986, Skarda and Freeman 1987, Stokoe 1989). Fundamental semantic relations such as antonymy are employed similarly across widely divergent cultures, suggesting a physiological base (Raybeck and Herrmann 1990). That the development of these semantic relations in children parallels cross-cultural patterns of

use, only strengthens this supposition (Landis, et al. 1987).

Others have argued that our ability to create symbols requires the construction of internal representations of the external world (Laughlin and D'Aquili 1974). This aptitude, in turn, involves associating information from various sensory modalities (taste, touch,sight, sound) in order to construct these representations of external stimuli(Ardila and Ostrosky-Solis 1989, Jerison 1990, Marin 1982). There is a neuron-rich area of the left hemisphere located in the folds of the Sylvan fissure that seems to be the site where various sensory information is cross-connected (Geschwind 1990, Laughlin and D'Aquili 1974). Termed the inferior parietal lobule (IPL), this structure seems to be an association area of association areas. Information entering the IPL from one sensory modality can be cross-referenced to other modalities. Theoretically this would permit the IPL to promote the construction of internal representations of the external world. Thus, the IPL seems to be deeply implicated in such curious events as synesthesia, where the information of one modality is registered as though it came from another (e.g. That sound is very bright.) However, the IPL is also the probable source of our mundane, yet very special ability to create symbols and to process cognitive distinctions.

Shorn of the preceding physiological details, it seems apparent that our communication and cognitive abilities have a distinctive structure, and a set of limits that are embedded in and reflective of our neurological substrate. There are limits to our ability to process information, to encode it and to decode it. Further, the rules of logic that underlie cognition as well as communication may also reflect a specific and delimited neurological substrate. It seems quite possible that, should we encounter an extraterrestrial intelligence, its communication and cognitive abilities may differ from our own in a fashion that would greatly impede inter-species communication.

PROBLEMS IN EXTRATERRESTRIAL COMMUNICATION

It seems fair to assume that any other life form we may encounter will be a product of a specific evolutionary past. Its capabilities and intelligence will be shaped by the environmental and selective pressures that characterize its planet of origin, and that will probably differ considerably from those forces under which our own species evolved. While there are grounds to believe that two intelligent species would share some aspects of perception, cognition and behavior, such as an appreciation of cause-effect, there is also reason to believe that intelligent species might exhibit significant differences in aspects of perception, cognition and behavior.

Evolution depends upon variable responses to selective pressures. Those

organisms that succeed evolutionarily do so by having more offspring and passing additional genetic information to future generations. The qualities that determine success are determined by the challenges that the organism faces, and these, in turn, reflect the nature of the environment (Cavalli-Sforza 1991, Gould 1977, Jerison 1990, Pribram 1986). Intelligence has been useful for humans, but ants have got on quite well with a set of communal, genetically based, responses to their environment. Other environments could presumably create evolutionary pressures quite different from those encountered on this planet. Beyond the assumption that there would be species competition (and that *is* an assumption), the manner in which a species would develop is quite unpredictable. On this planet there is a general evolutionary tendency for species to change in the direction of greater organismic complexity and greater size (within obvious limits).

Let us assume that we encounter an extraterrestrial life form that is markedly different from ourselves. As the product of its own evolutionary past, it too has a series of capacities and limits that are "wired in," and that differ from ours. Herein is a significant problem to cross-species understanding. The existing differences may be so fundamental that the basic problem may well be discovering the nature of the basic problem.

I know this suggestion runs counter to some science fiction notions that for communication with extraterrestrials all we need is an open mind and time to exchange simple messages. However, it is quite possible that the extraterrestrial life form will process more or fewer distinctions than we do, that its language production rules may differ, that the basic logic rules behind cognition and communication may be other than those with we are familiar. For instance, it may employ probabalistic fuzzy logic in place of our either-or reasoning. In short it is highly likely that this extraterrestrial will be *different*!

I know it is difficult to conceive of the nature of these differences, or of the ways in which they may be manifested; that is precisely the point - it is difficult. Perhaps some analogies can help to make my point.

In a "best case" scenario, it could well be possible to ascertain some of the differences that impede communication between our species and another. It is conceivable that certain of the differences will be sufficiently structured, regular and perceptible to be amenable to solution. Like the illustration below, the key to understanding may rest on a particular insight or the reformulation of a stricturing gestalt.

This illustration reflects several problems that are apt to arise in the process of attempted communication. First, the decoder is encouraged to make a perceptual assumption that the "message" consists of a series of stand-alone symbols. Second, the figure appears to contain symbolic references to information with which the reader is already familiar. Thus, the letter M, a heart, an 8 create the expectation that this is some form of combinational exercise that only needs to be decoded. Third, when initial attempts at solution fail, there is a tendency to try ever more complex variants of the attempt. Accordingly, one is encouraged to try permutations of what appear to be stand-alone symbols, e.g. the 8 combined with the M, etc. As the reader may have discerned, the solution to this puzzling communication depends on what psychologists term a gestalt reformulation, a new way of viewing the material. In this instance the principle of symmetry suggests an easy solution. However, one should not expect that novel principles would be as obvious in dealing with the communications of extraterrestrials.

It is also likely that the differences between ourselves and extraterrestrials will be sufficiently great that our very perceptual and cognitive equipment will differ in ways that greatly impede the likelihood of clear communication. For instance, assume that two women are communicating and that one, A, sees the full range of colors as we do, while the other, B, can only perceive black and white. As A and B converse, A continues to make references to the environment that B finds meaningless and necessarily puzzling. Further, A exhibits behaviors based on visual distinctions that elude B. A has a set of discriminations for which B lacks any perception. Even if B becomes aware that this is the case, B lacks the means to appreciate the distinctions because they do not register any information for her. Further, as Lakoff and others have demonstrated, A will employ metaphors based on sensory discriminations to convey more general cognitions (Lakoff 1987, Lakoff and Johnson 1980, Lakoff and Turner 1989). Thus, B will find references to 'feeling blue', 'seeing red,' 'green with envy,' etc. highly problematic and meaningless.

The preceding example is but a poor intimation of the sort of thing that may be expected to occur between two species. After all, the two women above share everything but color perception. In encountering extraterrestrial intelligence, it may be anticipated that we will share precious little, and that some of the differences will be much more profound than the example above suggests.

Thus, it may be the case that an extraterrestrial being will process more distinctions than we can recognize or will do so in a fashion that is foreign to us. Even among members of our own species there are significant differences in the ways in which we deal with information. For instance, navigation for members of Western

cultures involves a series of linear intellectual activities during which location is determined visually and intellectually through the use of a sextant and a clock. A ship's course is laid out in a linear fashion and the ship's progress is measured as movement along an imaginary line.

On some Micronesian Islands in the Pacific, there exists a set of navigational principles very dissimilar from those used in most Western cultures. Sailors are taught to integrate information from several sensory modalities in assessing their location as a dot in space. Thus a sailor from Puluwat attends to the feel of wind on his face, the sound of waves against his craft, and the appearance of the sky and clouds in determining his position, often sailing hundreds, even thousands, of miles between relatively tiny island landfalls (Gladwin 1970). He integrates all of this information in a processual fashion that differs markedly from the linear means employed by Westerners. Indeed, a Western navigator travelling on such a craft would not perceive, let alone understand, the means that the Puluwat sailor was using.

Now imagine that we are dealing with an extraterrestrial intelligence. Once again, the commonalties that the Western and Puluwat navigators share as members of the same species are absent, and differences will appear that much more opaque. Compared to us, the extraterrestrial may process more distinctions or fewer, may process them at a greater or lesser rate, in more or less complexity; and we will have a very difficult time ascertaining whether any or all of the preceding are the case.

A POSSIBLE SOLUTION TO COMMUNICATION PROBLEMS

At the start of this paper, I noted that there can be no communication unless there is at least a small degree of sharing. Indeed, the greater the amount of conjoint perceptual similarities, information processing techniques and capabilities, and environmental elements, the easier it should be to achieve accurate communication. It is because most of these elements will probably be idiosyncratic or, at best, minimally shared that the problem of communication with an extraterrestrial life form seems so daunting.

There are at least two major issues to overcome in communication with extraterrestrials: we must establish common ground with relatively unambiguous signals; and we must make every effort to eliminate or minimize the intrusion of background assumptions, ours and theirs, concerning the significance and meaning of messages and the components of messages. As Schank has noted, "A crucial feature of any understanding system is that it not use inappropriate conceptual tools to deal with a situation"(Schank and Childers 1984:123). A promising approach to these

difficulties involves the use of computers to reduce, and perhaps even eliminate, the communication problem.

For some time now, researches have employed computers to model and investigate human intelligence (Card, et al. 1983, Gardner 1985, Sauer and MacNair 1983, Schank and Abelson 1977, Schank and Colby 1973). In particular, there has been increasing interest in, and growing knowledge about, artificial intelligence, the use of computers to execute tasks that are generally held to reflect an understanding of an environment, an ability to effectively deal with the environment and even the capacity to learn from experience (Arbib, et al. 1982, Cottrell and Small 1983, Gardner 1985, Goldstein and Papert 1977, Marin 1982, Wasserman 1989).

Researchers have been interested in the use of computers to better under stand the human mind by attempting to model some of its basic abilities and even some of its neural structures (Arbib, et al. 1982, Ballard 1986, Nelson and Bower 1990, Wasserman 1989). Happily for our purposes, one of the areas of greatest investigation involves the use of computers in communications research, especially in efforts to approximate human language (Arbib, et al. 1982, Bolc 1978, Gardner 1985, Gerbner, et al. 1978, Hamburger and Crain 1987, Marin 1982, Schank and Childers 1984). One approach that has shown particular promise involves attempts to depart from strict parallel, sequential models and to approximate the operation and some of the structures of the human mind. As Cottrell has noted

> This modeling effort employs an architecture significantly different from the typical computer and closer to that of the human brain. The model uses a spreading activation or active semantic network scheme, called connectionism, which entails a massive number of appropriately connected computing units that communicate through weighted levels of excitation and inhibition. While such an architecture does not solve any problems *per se*, a number of questions are thought to become easier to set forth and more straightforward to solve (Cottrell and Small 1983 abstract).

This concept of using weighted levels of excitation and inhibition has been employed to construct what Wasserman (1989) terms neural networks. These are comparatively simple to construct and according to Wasserman, "Artificial neural networks can modify their behavior in response to their environment" (1989: 2). That is, they can learn and adapt to new circumstances as they are encountered. Furthermore, there now exist a set of algorithms that will produce unsupervised training in a computer (Wasserman 1989: 23). Effectively, this means that once a computer is given a start at a simple task it can continue to learn and to improve its performance on its own. It is this potential that gives rise to a computer solution for

our communication problems.

What follows is admittedly based on a reasoned extension of current knowledge but, as I have tried to indicate above, the projections below are grounded in existing technology and/or in logical extensions of such technology.

The solution to our extraterrestrial communication dilemma involves first programming a computer with a human language including, insofar as possible, cultural assumptions underlying language and language use (Diebold 1968, Whorf 1956). This means that a computer would be sensitive to connotative as well as to denotative meaning. In the latter instance, meaning is a simple association between the word and its referent. Thus, a pen is an implement containing ink and used for writing. Connotative meaning is much more complex and involves a set of active associations between the word, its referent and the cultural context that includes other referents and words. Hence, while two people agree that a given object is a pen, it *means* significantly different things if one person is a journalist and the other an illiterate. These linguistic abilities certainly exceed the capabilities of today's computers and computer programs, but those who are most active in this research seem to believe the preceding capacities can be realized (Card, et al. 1983, Corballis 1991, Hamburger and Crain 1987, Pinker 1979, Schank and Abelson 1977).

The establishment of a computer that can receive and generate complex messages in a human language is an important step toward our goal, but it obviously doesn't provide the solution. At this point we have simply shifted our unfamiliarity and lack of sharing from a human communicator to a machine.

Communication with extraterrestrials will necessarily involve establishing some common ground, however minimal. While I anticipate significant differences between us and them, I also expect that there should be some minimal sharing, if only because they too must process information, never mind that the processing techniques may differ greatly from our own. At the base of any information is contrast. This is a truism recognized in aphorisms ("There can be no joy without pain.") and in science. The fish in a bowl has no knowledge that it is wet for there is no contrast. According to physical scientists (Sagan 1973), social scientists (Laughlin and D'Aquili 1974, Levi-Strauss 1966), and philosophers (Brown 1963, Gardner 1985, Quine 1978), the most basic form of contrast is binary opposition. Something is, or is not; it is cold or hot, light or dark, etc.

There is also evidence that the perception and concept of antonymy is universal to human language (Raybeck and Herrmann 1990), and there is reason to expect that the principle of opposition upon which antonymy rests would be present in all communication systems. Thus, binary opposition provides a common reference point,

however basic and limited, on which communication between ourselves and extraterrestrials could be initiated.

As the reader is no doubt aware, binary opposition is also the basic process through which computers recognize and manage information. The current capabilities of computers (see above) are considerable. A computer can be given a learning algorithm that will enable it to learn new material and strategies, ultimately making significant improvement upon its programmed performance (Wasserman 1989). Therefore, it should be possible to begin with binary opposition as a common building block, and to conclude with a communication system of considerable complexity. We could start by instructing a computer to create a communication system using two simple instructions: assume antonomy, and grow increasingly complex. Such a program, would be far easier to accomplish in conjunction with a second computer operating with similar instructions.

Let us now assume an encounter between ourselves and an extraterrestrial life form. The differences and lack of sharing between us are enormous, and provide a significant hindrance to effective communication. However, both parties have communica tion machinery of the sort envisioned above. We interconnect our machines with instructions to create a *common* language, starting only with the assumption of opposition and a trend toward increasing complexity. When the machines are done they have a common language through which they can accurately commun icate. This language is shared *and* it lacks the sort of cultural assumptions that can confound early attempts at communication.

Further, both machines are adept at the languages of their respective creators and, thus, are capable of accurately translating from the shared machine language to the human or extraterrestrial language and vice versa. This means that, while the machine language does not contain culturally embedded assumptions, it can accurately translate such material, altering the specifics of the message in order to retain translation equivalence. In professional terms, the machines function as coordinate bilinguals, sensitive to each cultural context and capable of making appropriate changes in the original message, in order to convey the intended meaning in the second language (Diebold 1968).

Thus for instance, should an American or European somehow wish to send a valentine to an extraterrestrial, the computer will substitute the image of a heart with an arrow through it, for a representation that is less apt to be misunderstood. (I have always been bemused by our culturally embedded representation of true love. I presume an objective observer would assume that the message was not amour, but death.) Similarly, an extraterrestrial life form that viewed the termination of reproductive power as the equivalent of social maturity, might offer a salutation something like “May your gonads be removed.” Our computer may well choose to

render this as "Live long and prosper."

Once the preceding programs and capabilities are in place, communication between the two species should be able to proceed fairly efficiently and without egregious errors. Further, given their learning capabilities, computers should refine and improve the communication process over time. At some later point, it may be possible for the two species to communicate in a more direct fashion but, should the differences in cognitive and information processing abilities be significant, direct communication may never be feasible.

CONCLUSION

It is my hope that this paper proves useful to others concerned with SETI and allied fields. In evaluating the utility of this paper, my own verdict is somewhat mixed. I am confident that I have not overemphasized the difficulties we are apt to encounter should we attempt communication with extraterrestrial intelligence. For reasons having to do with our own evolution and the evolutionary processes that would produce life, there is reason to expect great differences between organ isms that evolve in different circumstances. Further, there is every likelihood that the cognitive capabilities and perceptual characteristics of extraterrestrials will be different from our own, and will be as structurally entrenched in them as ours are in us. Given these expectations, communications between two species face formidable obstacles indeed.

I am less sanguine about the proposed solution to these perceived communica tion problems. I do believe that computers have, or will have, the capabilities I have described above. I also believe that the kind of two-step trans lation process I have suggested is both reasonable and feasible. I even think it not improbable that another life form might reach a similar conclusion and design a parallel system. Finally, I am not particularly concerned about hardware compatibility since messaging could be carried out via microwaves, laser pulses, etc.

My biggest concern has to do with the initial effort at contact. It may not be possible to recognize that a message is being sent since there are a variety of media that could be employed, and there is a very real possibility that they will employ everyday media that we have yet to recognize. These could be communication channels that we would be slow to recognize, such as temperature fluctuations, vibrations or other means. More worrisome, however, is the very real possibility that they may employ a communication medium beyond both our experience and our current technological ability. How would we have responded a century ago to radio transmissions, a half-century ago to microwaves, a quarter-century ago to laser pulses? The obvious answer is we wouldn't have been aware that there was anything to which to respond. We can have no ability to recognize and deal with messages

conveyed through a medium which we have yet to discover.

A secondary concern, but also a possible one, is that extraterrestrials may not wish to communicate with us. Whether from fear, indifference, or a form of extraterrestrial "cool," it may be deemed undesirable to exchange messages; and necessarily information, with a brash and noisome species such as ourselves. If the universe is as full of rich and varied forms of intelligence as many suspect (Morrison, et al. 1977, Sagan 1973), we may simply be an insufficiently interesting opportunity for cross-species communication.

I have suggested several significant problems confronting attempts at communication with extraterrestrial intelligence. The reader may believe that these have been exaggerated or invented for the purposes of this paper. However, I would argue that the difficulties besetting efforts at cross-species communication will very likely be greater than those I have suggested. The reason for this expectation is simple: I am limited in my ability to imagine the unexperienced, as are we all.

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